Technical Assistance Services *for* Communities

West Lake Landfill Superfund Site

Fact Sheet #5 – September 2014

Health Risk-based Limits for Radionuclides in the Environment

Introduction

This fact sheet summarizes recommended and regulatory limits for human exposure to low levels of radionuclides based on the lifetime risk of getting cancer. The information provided is in response to community member questions and concerns about potential health effects from exposure to radionuclides possibly originating from the West Lake Landfill Superfund site. Therefore, the fact sheet focuses on limits for radium, thorium and uranium. The information is provided by the Technical Assistance Services for Communities (TASC) program. The fact sheet's contents do not necessarily reflect the opinions or position of the U.S. Environmental Protection Agency (EPA).

Cancer Risk Guidance for Superfund Sites

When making decisions about cleaning up a Superfund site, EPA generally considers that a cancer risk range of about 1 x 10^{-4} (1 in 10,000 people) to 1 x 10^{-6} (1 in a million people) for extra cancer cases due to exposure to contaminants at the site is acceptable. The upper limit of 1 in 10,000 is not an absolute value. EPA sometimes accepts higher cancer risk values for practical reasons. For example, at sites contaminated with radionuclides, EPA has considered cancer risk from radiation in a number of different contexts. EPA has consistently concluded that effective doses of 15 millirems per year or less are protective and achievable for cleanup of Superfund sites. EPA has explicitly rejected effective dose levels above 15 millirems per year as being not sufficiently protective.[1] A dose of 15 millirems per year is equal to an extra cancer risk of about 3 x 10^{-4} (3 in 10,000).[1]

Radionuclide Units of Measure

Millirems is a measure of the effective dose of radiation that a person could receive from a radioactive source. The amount of millirems (mrem) is calculated from the amount of picocurries. One way to visualize the difference between picocuries and millirem is to think of a campfire. The burning wood in the campfire radiates heat. The amount of fuel or burning wood is like the number of picocuries of radioactivity. The amount of heat (energy) given off by the campfire is like the number of millirems of radiation energy.

Decisions about the cleanup plan for the West Lake Landfill Superfund site are not final. Presently, cancer health risks from the site are considered very low because the area is fenced and signs are posted to keep people from

[1] U.S. Environmental Protection Agency. Memorandum – Establishment of Cleanup Levels at CERCLA Sites with Radioactive Contamination. August 22, 1997. http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/radguide.pdf

being exposed to soil on site. Air monitoring and gamma radiation surveys to date have not shown any reason to think that there is an unacceptable cancer risk in the surrounding communities from radioactive contamination at West Lake Landfill. EPA has checked that ground water from under the site is not being used as a drinking water source.

Guidance for the Home and Workplace

Limits for Radionuclides in Soil

EPA calculates preliminary remediation goals (PRGs) for soil at Superfund sites to first evaluate if further investigation of soil is needed. PRGs are not background levels or cleanup standards. PRGs are used to help identify areas, contaminants and conditions that do not require further federal attention.[2] If contaminants at a site exceed generic PRGs, more investigation typically follows. The next step is then a cleanup plan, which includes site-specific cleanup goals for soil based on current and future use plans.

TASC used an online EPA calculator at http://epa-prgs.ornl.gov/radionuclides to calculate the PRGs shown in Table 1 below using default values in the calculator. The default PRGs are calculated for a cancer risk of one in a million extra cancer cases. For EPA action levels at the upper risk level of 1 in 10,000 extra cancer cases, the values from the calculator are multiplied by 100. TASC calculated generic PRGs for radium, thorium and uranium isotopes in soil for residents and outdoor workers, as shown in the table below. These generic values consider risks from ingestion (accidently eating contaminated soil particles), inhalation (breathing contaminated dust particles that become airborne) and direct exposure to radiation energy. The PRGs for residents are smaller than for outdoor workers because residents are assumed to spend more time exposed to the soil than outdoor workers.

Table 1. Generic PRGs for Soil[2]

Radionuclide	Residents		Outdoor Workers	
Radium-226+D	0.012 pCi/g	1.2 pCi/g	0.025 pCi/g	2.5 pCi/g
Radium-228+D	0.029 pCi/g	2.9 pCi/g	0.054 pCi/g	5.4 pCi/g
Thorium-230	3.46 pCi/g	346 pCi/g	20 pCi/g	2000 pCi/g
Uranium-238+D	0.70 pCi/g	70 pCi/g	1.65 pCi/g	165 pCi/g
Calculated Cancer Risk	*1 in a million*	*1 in 10,000*	*1 in a million*	*1 in 10,000*

pCi/g = picocuries per gram of soil
+D means daughter products from decomposition are included

Limits for Radionuclides in Indoor Air

Although breathing dust particles containing radium, thorium or uranium could be harmful to people's health, there are no indoor air regulations specifically for these compounds because they exist as solids in the natural environment. As noted in the previous section, there are PRGs for inhalation of soil radionuclides. When radium decomposes, it forms a gas called radon. There is a worker safety limit for radon in the workplace and recommended limits for radon in homes.

[2] U.S. Environmental Protection Agency. Preliminary Remediation Goals for Radionuclides. http://epa-prgs.ornl.gov/radionuclides

The average indoor radon level is estimated to be about 1.3 picocuries per liter of air (pCi/L). About 0.4 pCi/L of radon is normally found in the outside air.[3]

The Occupational Safety and Health Administration (OSHA) has a workplace exposure limit of 100 piCi/L for 40 hours over seven consecutive workdays.[4]

EPA has set a standard for radon gas in the air in homes at 4 pCi/L and recommends that homeowners address the situation if radon is above 2 pCi/L.[3] Lowering radon levels below 2 pCi/L is difficult.

If 1,000 people who smoked were exposed to 4 pCi/L of radon in their homes for a lifetime, EPA estimates that 62 of these people could get lung cancer. For nonsmokers exposed to 4 pCi/L of radon in their homes for a lifetime, about seven people in 1,000 could get lung cancer.[3]

Limits for Radionuclides in Drinking Water

EPA limits the amounts of certain radionuclides in drinking water.[5] These limits are summarized below. Ground water from below the West Lake Landfill Superfund site is not being used for drinking water, but drinking water standards are sometimes used as cleanup goals for ground water.

Alpha particles* = 15 picocuries/Liter of water (pCi/L)
Beta particles* and photon emitters = 4 millirems/year
Radium-226 and Radium-228 (combined) = 5 pCi/L
Uranium = 30 micrograms/liter of water

* When radionuclides decay, they emit radiation in the form of alpha particles, beta particles or gamma radiation (photons). The type and amount of radiation depends on the specific radionuclide.

The extra lifetime risk of cancer from exposure to drinking water with the listed amounts of radionuclides is roughly 1 x 10^{-4} (1 in 10,000).

How are Picocuries and Millirems Related?

As explained in the text box on page one, radioactivity of a material is measured in picocuries (pCi). The effective doses of radiation from any source are measured in millirems (mrem). The calculation of mrem from picocurries in air, water or soil is complex and depends on the specific radionuclide(s) involved.

Common Doses of Radiation in the United States

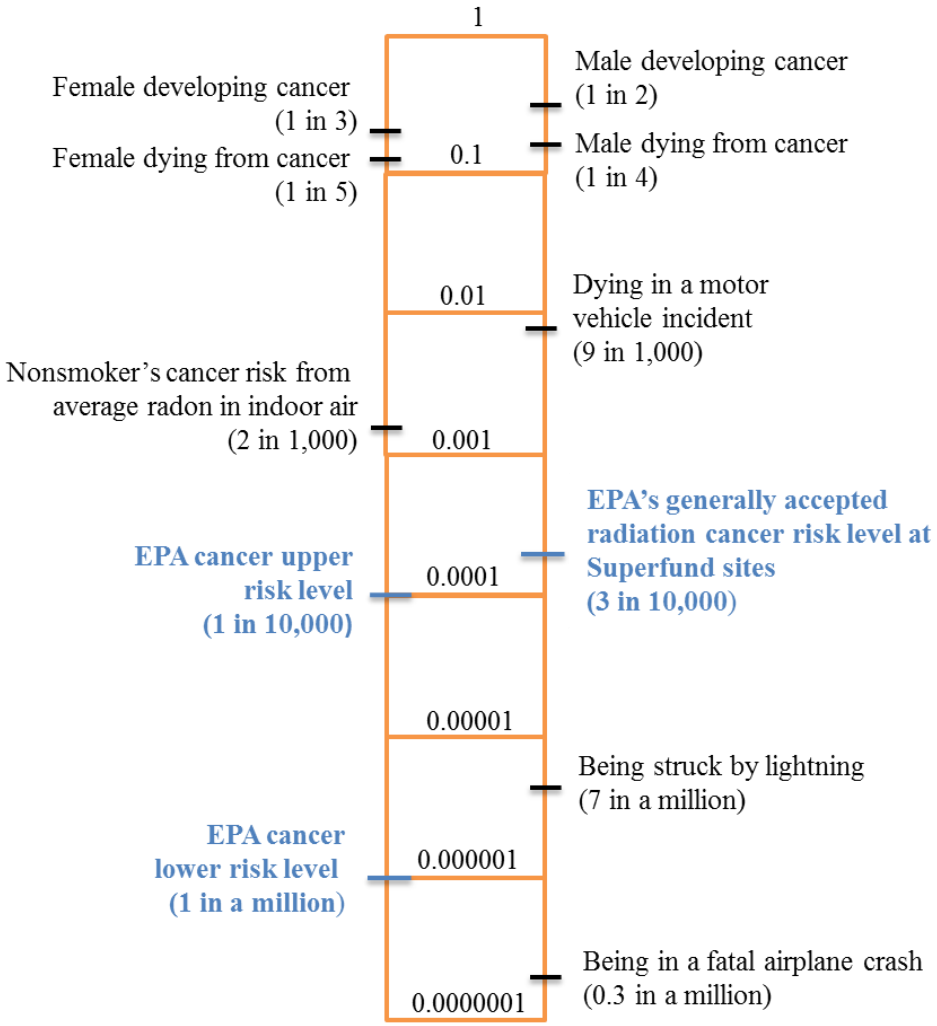
The average person in the United States receives about 620 millirems of radiation per year.[6] About half of this dose comes from natural background radiation, mostly from radon in the air. The rest comes from manmade sources such as medical, industrial and commercial equipment. About 30 millirems per year are from the food and water that we eat and drink.

[3] U.S. Environmental Protection Agency. A Citizen's Guide to Radon. http://www.epa.gov/radon/pubs/citguide.html
[4] Office of Compliance. Fact Facts: Indoor Air Quality – Radon. http://www.compliance.gov/forms-pubs/eresources/fastfacts_radon.pdf
[5] U.S. Environmental Protection Agency. Drinking Water Contaminants. http://water.epa.gov/drink/contaminants
[6] U.S. Nuclear Regulatory Commission. http://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html

A Perspective on Risk

Figure 1 below shares some statistics that may help put lifetime risk of cancer from exposure to specific contaminants in perspective with other types of lifetime risks. The values in the figure are presented on a logarithmic scale because the numbers vary so greatly that the smaller numbers would not show up on a normal scale graphic.

Figure 1. Lifetime Risks



Data Sources:

a. http://www.nsc.org/news_resources/injury_and_death_statistics/Documents/2014-Injury-Facts-43.pdf
b. http://www.planecrashinfo.com/cause.htm
c. http://www.epa.gov/radon/healthrisks.html
d. http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/radguide.pdf

Potential health effects from exposure to high levels of radiation are shown in Table 2 below. Potential health effects from exposure to the radiation level generally allowed to remain at Superfund sites (15 mrem) is estimated at about 3 extra cases of cancer per 10,000 people.

Table 2. Health Effects from Exposure to Radiation

Exposure (mrem)	Health Effect	Time to Onset (without treatment)
15	*Radiation level generally considered protective and achievable for cleanup of Superfund sites*	
5,000-10,000	changes in blood chemistry	
50,000	nausea	hours
55,000	fatigue	
70,000	vomiting	
75,000	hair loss	2-3 weeks
90,000	diarrhea	
100,000	hemorrhage	
400,000	possible death	within 2 months
1,000,000	destruction of intestinal lining internal bleeding and death	1-2 weeks
2,000,000	damage to central nervous system loss of consciousness; and death	minutes hours to days
Source: US EPA. ***Adapted from http://www.epa.gov/radiation/understand/health_effects.html***		

EPA notes on this webpage, http://www.epa.gov/radiation/understand/risk.html, that most radiation protection organizations estimate the risk of health effects from low levels of exposure, all the way to zero exposure, as proportional to those of high levels of exposure. This method of estimating risk is called the 'linear no-threshold model.' It assumes there is no 'threshold,' that is to say there is no exposure level below which the risk is zero. It also assumes that the risk increases in proportion to the exposure. If the exposure doubles, the risk also doubles. Some scientists strongly dispute the no-threshold assumption.